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(54) PRODUCTION OF FE-BASE SINTERED ALLOY MEMBER HAVING HIGH STRENGTH AND HIGH TOUGHNESS

(57) Abstract:

PURPOSE: To produce Fe-base sintered alloy member having high strength and high toughness by granulating the Fe-base alloy ne powder to the Fe-base alloy coarse powder so as to become the speci c coarse particle degree, mixing the granulated powder and the coarse powder at the speci c ratio, compacting and sintering.

CONSTITUTION: The Fe-base alloy coarse powder having relatively coarse particle size (for example, about 80W350 mesh particle size and about 80μ average particle diameter) and the Fe-base alloy ne powder having ne particle size (for example, about minus 635 mesh particle size and about 8μ average particle diameter) are prepared as the raw material powder. By burning this Fe-base alloy ne powder or by using binder, the granulation is executed to average diameter corresponding to about 20W40% of the average diameter of the Fe-base alloy coarse powder. Next, after mixing so as to become the blending ratio of 70W90 wt.% the coarse powder and 10W30 wt.% the granulated powder, it is compacted to the green compact and sintered. By this method, the Fe-base sintered alloy member having high strength, high toughness, high density and extremely small rate of size changing is obtd. and at the time of applying it to the mechanical structure member, excellent characteristic is obtd. for a long time.

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審査請求　未請求　発明の数 1　（全4頁）

㊹発明の名称　高強度および高靱性を有するFe系焼結合金部材の製造法

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明　細　書

1. 発明の名称

高強度および高靱性を有するFe系焼結合金部材の製造法

2. 特許請求の範囲

原料粉末として、相対的に粒径の粗いFe系合金粗粉末と、粒径の細かいFe系合金微粉末を用意し、

上記の粒径の細かいFe系合金微粉末を、仮焼によるか、あるいは結合材を用いるかして、上記の粒径の粗いFe系合金粗粉末のもつ平均粒径の20～40％に相当する平均粒径に造粒し、

上記のFe系合金粗粉末：70～90重量％、

上記のFe系合金造粒粉末：10～30重量％、

の配合組成に配合し、

以後、通常の条件で、混合し、圧粉体に成形し、ついでこれを焼結することを特徴とする高強度および高靱性を有するFe系焼結合金部材の製造法。

3. 発明の詳細な説明

〔産業上の利用分野〕

この発明は、高強度および高靱性を有し、各種の機械部品などとして適用されるFe系焼結合金部材の製造法に関するものである。

〔従来の技術〕

一般に、上記のFe系焼結合金部材は、原料粉末として、所定の成分組成を有し、かつ70～100μm程度の平均粒径をもったFe系合金粉末を用い、これを通常の条件、すなわち約5～6 ton/cm²の圧力で圧粉体に成形し、この圧粉体を非酸化性雰囲気中、1100～1150℃の温度で焼結することによつて製造されている。

〔発明が解決しようとする問題点〕

しかし、上記の従来法により製造されたFe系焼結合金部材においては、強度および靱性のいずれも満足するものではなく、ましてや近年の軽量化、省力化、および高性能化の要求とも合まつて、一段と高強度および高靱性を有するFe系焼結合金部材の製造が強く望まれているのが現状である。

〔問題点を解決するための手段〕

そこで、本発明者等は、上述のような観点から、高強度および高靱性を有するFe系焼結合金部材を製造すべく研究を行なつた結果、

上記の従来法で製造されたFe系焼結合金部材の強度および靱性が不十分なのは、Fe系焼結合金部材、なかんずく、その圧粉体に存在する空孔が粗大にして不均一であることに原因するが、

原料粉末として、相対的に粒径の粗いFe系合金粗粉末と、粒径の細かいFe系合金微粉末を用い、

上記の粒径の細かいFe系合金微粉末を、仮焼によるか、あるいは結合材を用いるかして、上記の粒径の粗いFe系合金粗粉末の平均粒径の20～40%に相当する平均粒径に造粒し、

上記のFe系合金粗粉末：70～90重量%、

上記のFe系合金造粒粉末：10～30重量%、

の割合に配合し、通常の条件で、混合し、この混合粉末より成形した圧粉体においては、上記の相対的に粒径の粗いFe系合金粗粉末間に形成された空孔内に、前記Fe系合金粗粉末のもつ平均粒径の20～40%に相当する平均粒径を有する、相対的に粒径の細かい上記Fe系合金造粒粉末が配された粉末配置構造をもつようになるために、空孔はきわめて微細化されたものとなり、この状態の圧粉体を焼結すると、前記微細化した空孔は球状化し、高い密度をもつようになることから、この結果のFe系焼結合金部材は高強度と高靱性をもつようになる極か、寸法変化も小さいという知見を得たのである。

この発明は、上記知見にもとづいてなされたものであつて、

原料粉末として、相対的に粒径の粗いFe系合金粗粉末と、粒径の細かいFe系合金微粉末を用意し、

上記の粒径の細かいFe系合金微粉末を、仮焼によるか、あるいは結合材を用いるかして、上記の粒径の粗いFe系合金粗粉末のもつ平均粒径の20～40%に相当する平均粒径に造粒し、

上記のFe系合金粗粉末：70～90重量%、

上記のFe系合金造粒粉末：10～30重量%、

の配合組成に配合し、

以後、通常の条件で、混合し、圧粉体に成形し、ついでこれを焼結することによつて、高強度および高靱性を有し、かつ寸法変化も小さいFe系焼結合金部材を製造する方法に特徴を有するものである。

この発明の方法において、Fe系合金造粒粉末の平均粒径を、Fe系合金粗粉末のもつ平均粒径の20～40%(以下、相対平均粒径比という)と限定したのは、20%未満の相対平均粒径比では、Fe系合金粗粉末との均質な混合が困難で、均一な粉末配置構造の圧粉体、すなわちFe系合金粗粉末間に形成される空孔を前記Fe系合金造粒粉末で十分に埋めた圧粉体を成形することができず、したがつてこの結果の圧粉体を焼結しても高強度および高靱性を有するFe系焼結合金部材は得られないものであり、一方40%を越えた相対平均粒径比になると、粒径が大きすぎてFe系合金粗粉末間に形成される空孔におさまることができず、かえつてこれを離す方向に作用し、Fe系焼結合金部材における前記Fe系合金粗粉末による骨格形成が不十分となり、高密度が得られないことから、強度および靱性の改善ができないという理由によるものであり、また、配合組成を、重量%で、

Fe系合金粗粉末：70～90%、

Fe系合金造粒粉末：10～30%、

としたのは、Fe系合金粗粉末の割合が70%未満では、相対的にFe系合金造粒粉末の割合が30%を越えて高くなりすぎ、Fe系合金粗粉末間に形成される空孔を埋めた上で、さらに余分のFe系合金造粒粉末が存在するようになり、この状態の圧粉体を焼結すると、寸法変化が大きくなつて望ましくなく、一方Fe系合金粗粉末の割合が90%を越えると、相対的にFe系合金造粒粉末の割合が10%未満と低くなりすぎてしまい、Fe系合金造粒粉末でFe系合金粗粉末間に形成される空孔を完全に埋め、もつてこの空孔の十分な微細化をはかることができなくなり、この状態の圧粉体の焼結では、高強度化および高靱性化が不十分で、かつ寸法変化を低くおさえることができないという理由にもとづくものである。

〔実施例〕

つぎに、この発明の方法を実施例により具体的に説明する。

実施例 1

原料粉末として、いずれもNi：2.1％、Mo：0.5％、C：0.6％を含有し、残りがFeと不可避不純物からなる組成（以上重量％）を有し、かつ80～350メッシュの粒度範囲で、平均粒径が80μmの相対的に粒径の粗いFe系合金粗粉末と、635メッシュ以上の粒度範囲で、平均粒径が8μmの粒径の細かいFe系合金微粉末とを用意し、

ついで、上記Fe系合金微粉末を、所定の粒径に造粒し、これを還元性雰囲気中、温度：750℃で仮焼して、それぞれ第1表に示される相対平均粒径比をもった各種のFe系合金造粒粉末を成形し、

このFe系合金造粒粉末を、同じく第1表にそれぞれ示される配合割合で前記Fe系合金粗粉末に配合し、さらに上記のFe系合金粗粉末およびFe系合金微粉末におけるC含有量は、目標C含有量に対して0.2％不足するので、この分の炭素粉末と、潤滑剤としてのステアリン酸亜鉛粉末：1％とを添加し、通常の条件で、1時間混合し、この混合粉末を振動を加えながら金型に充填し、6 ton/cm²の圧力で直径：11.3mm×長さ：10mmの寸法をもった圧粉体に成形し、この圧粉体を、窒素雰囲気中、温度：1130℃に30分間保持の条件で焼結することによって本発明法1～8および比較法1～5を実施し、各種のFe系焼結合金部材を製造した。

なお、比較法1～4は、いずれもFe系合金造粒粉末の相対平均粒径比および配合量のいずれかがこの発明の範囲から外れたものであり、また比較法5は、原料粉末として、上記のFe系合金造粒粉末の配合を行なわず、上記のFe系合金粗粉末のみを用いた従来法に相当するものである。

実施例 2

Fe系合金造粒粉末の成形に、仮焼に代つて、結合材として2重量％のレジンを使用し、さらにこの結果のFe系合金造粒粉末の相対平均粒径比および配合量を第2表に示されるものとし、かつ前記

第1表

種別		Fe系合金造粒粉末		Fe系焼結合金部材				
		相対平均粒径比（％）	配合量（重量％）	引張強さ（kgf/mm²）	伸び（％）	衝撃値（kgf-m/cm²）	密度（g/cm³）	寸法変化率（％）
本発明法	1	20	20	48	8.5	5.0	7.2	-0.06
	2	30	15	49	8.3	5.0	7.2	+0.01
	3	30	25	50	9.0	4.9	7.2	-0.06
	4	24	20	49	9.1	5.2	7.2	-0.04
	5	35	20	51	8.9	4.9	7.2	-0.08
	6	40	20	50	8.7	4.7	7.2	-0.06
	7	30	10	47	7.8	4.2	7.1	+0.04
	8	30	30	51	9.0	5.1	7.2	-0.12
比較法	1	30	5*	44	4.1	2.4	7.0	+0.08
	2	30	40*	52	9.2	5.2	7.3	-0.32
	3	10*	20	46	5.8	3.5	7.1	-0.12
	4	52*	20	45	5.1	2.8	7.0	-0.07
	5	-	-	43	3.5	2.2	7.0	+0.11

（*印：本発明範囲外）

第2表

種別		Fe系合金造粒粉末		Fe系焼結合金部材				
		相対平均粒径比（％）	配合量（重量％）	引張強さ（kgf/mm²）	伸び（％）	衝撃値（kgf-m/cm²）	密度（g/cm³）	寸法変化率（％）
本発明法	9	20	20	48	8.6	4.9	7.1	-0.10
	10	29	15	49	8.5	5.1	7.2	+0.03
	11	29	25	52	9.2	5.1	7.2	-0.05
	12	27	20	50	9.1	5.3	7.2	-0.07
	13	35	20	51	8.6	5.0	7.2	-0.09
	14	40	20	49	8.3	4.5	7.2	-0.08
	15	29	10	47	7.5	4.4	7.2	+0.08
	16	29	30	52	9.2	5.2	7.2	-0.10
比較法	6	29	5*	43	3.9	2.3	7.0	+0.12
	7	29	40*	53	9.0	5.3	7.2	-0.36
	8	12*	20	48	5.3	3.4	7.1	-0.12
	9	54*	20	46	5.5	3.0	7.0	-0.09

（*印：本発明範囲外）

レジンを圧粉体に成形後に、還元性雰囲気中、温度：650℃に2時間保持の条件で除去する以外は、実施例1におけると同一の条件で本発明法9～16および比較法6～9をそれぞれ実施し、Fe系焼結合金部材を製造した。

つぎに、この結果得られた各種のFe系焼結合金部材について、引張強さ、伸び、衝撃値、密度、および長さ方向の寸法変化率を測定し、それぞれ第1表および第2表に示した。

〔発明の効果〕

第1表および第2表に示される結果から、本発明法1～16で製造されたFe系焼結合金部材は、比較法5（従来法）で製造されたものに比して、一段とすぐれた特性、すなわち高強度、高靭性、および高密度を有し、さらに寸法変化率もきわめて小さいものであるのに対して、比較法1～9で製造されたFe系焼結合金部材に見られるように、Fe系合金造粒粉末の相対平均粒径比および配合量のいずれかでもこの発明の範囲から外れると、上記の特性のうち少なくともいずれかの特性が劣るようになることが明らかである。

上述のように、この発明の方法によれば、高強度、高靭性、および高密度を有し、かつ寸法変化率のきわめて小さいFe系焼結合金部材を製造することができ、したがってこれを機械構造部品などとして適用した場合に、すぐれた性能を著しく長期に亘って発揮するようになるなど工業上有用な効果がもたらされるのである。

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(54) [Title of the Invention] A manufacturing method of an Fe-base sintered alloy member having high strength and toughness

[Specification]

[Title of the Invention] A manufacturing method of an Fe-base sintered alloy member having high strength and toughness

[Scope of Patent Claims]

[Claim 1] A manufacturing method of an Fe-base sintered alloy member with high strength and toughness, said manufacturing method characterized by a process comprising: preparing an Fe-base alloy coarse powder of relatively coarse particle size and an Fe-base alloy fine powder of fine particle size as the raw material powder; granulating said Fe-base alloy fine powder to have an average diameter corresponding to 20-40% of the average diameter of said Fe-base alloy coarse powder of coarse particle size through preliminary sintering or use of a binder; blending so as to obtain a ratio of 70-90 wt% of said Fe-base alloy coarse powder and 10-30 wt% of said Fe-base alloy fine powder; mixing under normal conditions; molding to form the compact; and sintering the compact.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to a manufacturing method of an Fe-base sintered alloy member having high strength and toughness as applied in various machine components and the like.
[0002]
[Prior Art] In general, said Fe-base sintered alloy member is manufactured by using Fe-base alloy powder with an average particle size of 70-100 μm at the specific composition ratio as the raw material powder, molding to the compact under normal conditions, that is, under approximately 5-6 ton/cm² pressure, and then sintering the compact at 1100-1150°C in a non-oxygenated atmosphere.
[0003]
[Problem to be Solved by the Invention] However, the strength and toughness of the Fe-base sintered alloy member manufactured by said conventional method is not satisfactory. Furthermore, in combination with recent demands for conservation of weight and energy, as well as high-performance, present circumstances have resulted in a strong desire for the manufacture of an Fe-base sintered alloy member with higher strength and toughness.
[0004]
[Means for Solving the Problem] From said point of view, the inventors of the present invention have undertaken research to manufacture an Fe-base sintered alloy member with high strength and toughness. As a result, findings were obtained indicating that the insufficient strength and toughness of the Fe-base sintered alloy member manufactured by said conventional method derived from the fact that holes present in the Fe-base sintered alloy member, especially in the compact thereof are large and uneven. However, regarding a compact prepared by using an Fe-base alloy coarse powder of relatively coarse particle size and an Fe-base alloy fine powder of fine particle size as the raw material powder, granulating said Fe-base alloy fine powder to an average particle size corresponding to 20-40% of the average particle size of said Fe-base alloy coarse powder of coarse particle size by preliminary sintering or the use of a binder, blending so as to obtain a ratio of 70-90 wt.% of said Fe-base alloy coarse powder and 10-30 wt.% of said Fe-base alloy fine powder, mixing under normal conditions, and molding from the mixed powder, the compact has a powder alignment in which said Fe-base alloy granulated powder of fine particle size corresponding to 20-40% of the average particle size of said Fe-base alloy coarse powder is located in the holes formed among said Fe-base alloy coarse particles having relatively coarse particle size. Therefore, the holes are extremely miniaturized. When sintering the compact in such condition, said miniaturized holes are spheroidized and given high density. Consequently, the resulting Fe-base sintered alloy member comes to have high strength and toughness as well as a small rate of changing in size.
[0005]
The present invention is based on said findings and characterized by the manufacturing method of an Fe-base sintered alloy member having high strength and toughness as well as a small rate of changing in size, wherein said manufacturing method is comprised of preparing an Fe-base alloy coarse powder of relatively coarse particle size and an Fe-base alloy fine powder of fine particle size as the raw material powder, granulating said Fe-base alloy fine powder to an average particle size corresponding to 20-40% of the average particle size of said Fe-base alloy coarse powder of coarse particle size by preliminary sintering or the use of a binder, blending so as to obtain a ratio of 70-90 wt% of said Fe-base alloy coarse powder and 10-30 wt% of said Fe-base alloy fine powder, mixing under normal conditions, molding the mixed powder to form the compact, and sintering the compact.

[0006]
In the method of the present invention, the average particle size of the Fe-base alloy granulated powder was determined to be 20-40% of the average particle size of the Fe-base alloy coarse powder (hereinafter, referred to as the relative average particle size ratio). The reason is that it is difficult to evenly mix with the Fe-base alloy coarse powder at under 20% of the relative average particle size ratio, and it is also impossible to mold a compact having an even powder alignment, that is, the compact in which the holes formed among the Fe-base alloy coarse powders are sufficiently filled with said Fe-base alloy granulated fine powder. Therefore, even if sintering the resulting compact, an Fe-base sintered alloy member having high strength and toughness cannot be obtained. On the other hand, with a size of 40% or more of the relative average particle size ratio, the particle size is too big to fit in the holes formed among the Fe-base alloy coarse powder. Rather, the particles act in a direction to separate, which interferes with sufficient backbone formation by said Fe-base alloy coarse powder in the Fe-base sintered alloy member. Therefore, it is unable to obtain high density or improve the strength and toughness. In addition, the blending ratio was set to be 70-90 wt% of said Fe-base alloy coarse powder and 10-30 wt.% of said Fe-base alloy fine powder. The reason is that by making the percent of Fe-base alloy coarse powder less than 70%, the ratio of the Fe-base alloy granulated powder exceeds 30%, which is too high. In this case, the Fe-base alloy granulated powder fills in the holes formed among the Fe-base alloy coarse powder and, further, the excess Fe-base alloy granulated powder remains. If sintering the compact in this condition, the changing in size unpreferably increases. On the other hand, using 90% or more of the Fe-base alloy coarse powder, the ratio of the Fe-base alloy granulated powder decreases to under 10%, which is too low. As a result, it is impossible to completely fill in the holes formed among the Fe-base alloy coarse powder with the Fe-base alloy granulated powder, which inhibits sufficient miniaturization of the holes. Accordingly, sintering the compact in this condition cannot achieve sufficient high strength and toughness or maintain a low rate of changing in size.
[0007]
[Embodiments of the Invention] Next, the method of the present invention will be specifically explained in reference to the embodiments.
[0008]
[Embodiment 1] As the raw material powder, prepare an Fe-base alloy coarse powder having a composition (shown as wt.%) that contains Ni: 2.1%, Mo: 0.5%, C: 0.6%, and the rest comprising Fe and unavoidable impurities, with an average 80μm of relatively coarse particle size in a range of 80-350 mesh particles as well as an average 80μm of relatively fine particle size with 635 mesh or higher. Next, granulate said Fe-base alloy fine powder of a specific particle size. Mold various Fe-base alloy granulated powders with the relative average particle size ratio shown in Table 1 respectively by preliminary sintering said Fe-base alloy fine powder of a specific particle size in a reducing atmosphere at 750°C. Blend the resulting Fe-base alloy granulated powder with said Fe-base alloy coarse powder in the respective combination ratio shown in Table 1. Further, since the C content in said Fe-base alloy coarse powder and the Fe-base alloy fine powder is insufficient by 0.2% of the target C content, add the insufficient amount of carbon powder and 1% of zinc stearate powder as a lubricant and mix it for 1 hour under normal conditions. Fill the mixed powder in a mold while shaking, and mold a compact having the dimensions of diameter: 11.3 nm x length: 10nm under 6 ton/cm² pressure. By sintering the compact while maintaining conditions at 1130°C for 30 minutes in a nitrogen

atmosphere, the methods 1-8 of the present invention and the comparative methods 1-5 are performed to produce various Fe-base sintered alloy members.

[0009]

In each of the comparative methods 1-4, either the relative average particle size ratio or the blending quantity of the Fe-base alloy granulated powder deviates from the range of the present invention. Comparative method 5 is equivalent to the conventional method whereby said Fe-base alloy granulated powder is not mixed as the raw material powder.

[0010]

[Embodiment 2] Instead of preliminary sintering, use 2 wt% of resin as a binder for molding the Fe-base alloy granulated powder. Furthermore, employ the relative average particle size ratio and the blending quantity of the resulting Fe-base alloy granulated powder shown in Table 2. After molding said resin to the compact, the methods 9-16 and the comparative methods 6-9 are conducted to produce an Fe-base sintered alloy member under the same conditions as Embodiment 1, with the exception of removal in a reducing atmosphere while maintaining conditions of 650°C for 2 hours.

[Table 1] (*: out of the scope of the present invention)

Type		Fe-base alloy granulated powder		Fe-base sintered alloy member				
		Relative average particle size ratio (%)	Blending quantity (wt%)	Tensile strength (Kgf/cm^2)	Stretch (%)	Impact value (Kgf-m/cm^2)	Density (g/cm^2)	Size changing rate (%)
Method of the present invention	1	20	20	48	8.5	5.0	7.2	-0.06
	2	30	15	49	8.3	5.0	7.2	+0.01
	3	30	25	50	9.0	4.9	7.2	-0.06
	4	24	20	49	9.1	5.2	7.2	-0.04
	5	35	20	51	8.9	4.9	7.2	-0.08
	6	40	20	50	8.7	4.7	7.2	-0.08
	7	30	10	47	7.8	4.2	7.1	+0.04
	8	30	30	51	9.0	5.1	7.2	-0.12
Comparative invention	1	30	5*	44	4.1	2.4	7.0	+0.08
	2	30	40*	52	9.2	5.2	7.3	-0.32
	3	10*	20	46	5.8	3.5	7.1	-0.12
	4	52*	20	45	5.1	2.8	7.0	-0.07
	5	-	-	43	3.5	2.2	7.0	+0.11

[Table 2] (*: out of the scope of the present invention)

Type	Fe-base alloy granulated powder	Fe-base sintered alloy member

		Relative average particle size ratio (%)	Blending quantity (wt%)	Tensile strength (Kgf/cm^2)	Stretch (%)	Impact value (Kgf-m/cm^2)	Density (g/cm^2)	Size changing rate (%)
	9	20	20	48	8.5	4.9	7.1	-0.10
	10	29	15	49	8.5	5.1	7.2	+0.03
	11	29	25	52	9.2	5.1	7.2	-0.05
	12	27	20	50	9.1	5.3	7.2	-0.07
	13	35	20	51	8.6	5.0	7.2	-0.09
	14	40	20	49	8.3	4.5	7.2	-0.08
	15	29	10	47	7.5	4.4	7.2	+0.08
	16	29	30	52	9.2	5.2	7.2	-0.10
	6	29	5*	43	3.9	2.3	7.0	+0.12
	7	29	40*	53	9.0	5.3	7.2	-0.38
	8	12*	20	48	5.3	3.4	7.1	-0.12
	9	54*	20	46	5.5	3.0	7.0	-0.09

[0011]
[Effects of the Invention] Based on the results shown in Table 1 and Table 2, the Fe-base sintered alloy member manufactured by methods 1-16 of the present invention has greater properties, that is, high strength, high toughness, and high-density and, further, an extremely small rate of changing in size, in comparison with that manufactured by the comparative method 5 (conventional method). On the other hand, as observed in the Fe-base sintered alloy member manufactured by the comparative methods 1-9, it is obvious that at least any of said properties deteriorates when either the relative average particle size ratio or the blending quantity of the Fe-base alloy granulated powder deviates from the scope of the present invention.
[0012]
As mentioned above, according to the method of the present invention, it is possible to manufacture an Fe-base sintered alloy member having high strength, high toughness, high density and extremely small rate of changing in size. Consequently, this method yields industrially useful effects, for example, when applying it to mechanical structure members, as excellent characteristics can be obtained for a significantly long time.

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